Topic B – Part 9
Respiration

IB Chemistry

Topic B – Biochem

B9 - Respiration

- B.9.1 Compare aerobic and anaerobic of glucose in terms of oxidation/reduction and energy released
- B.9.2 Outline the role of copper ions in electron transport and iron ions in oxygen transport

B9.1 – Aerobic v. Anaerobic

- B.9.1 Compare aerobic and anaerobic of glucose in terms of oxidation/reduction and energy released

B9.1 - Respiration

- **Cellular Respiration** is the chemical reactions occurring inside living cells that result in the release of energy.
- Controlled by enzymes and occurs under two conditions
  - **Anerobically** – no molecular oxygen required
  - **Aerobically** – molecular oxygen required

B9.1 – Aerobic Respiration

- **Aerobic** Respiration
  - In plants and animals
    - $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
- The enzymes involved are present in the cytoplasm and mitochondria of the cells. Mitochondria are membrane-bound structures involved with aerobic respiration, in particular **electron transport chain**. The glucose is oxidized and the oxygen is reduced

B9.1 – Anaerobic Respiration

- In plants and yeast, in the absence of oxygen
  - $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$
  - This is the basis for fermentation
- In animals
  - $C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$
  - This is the basis for lactic acid fermentation

B9.1 – Anaerobic v Aerobic

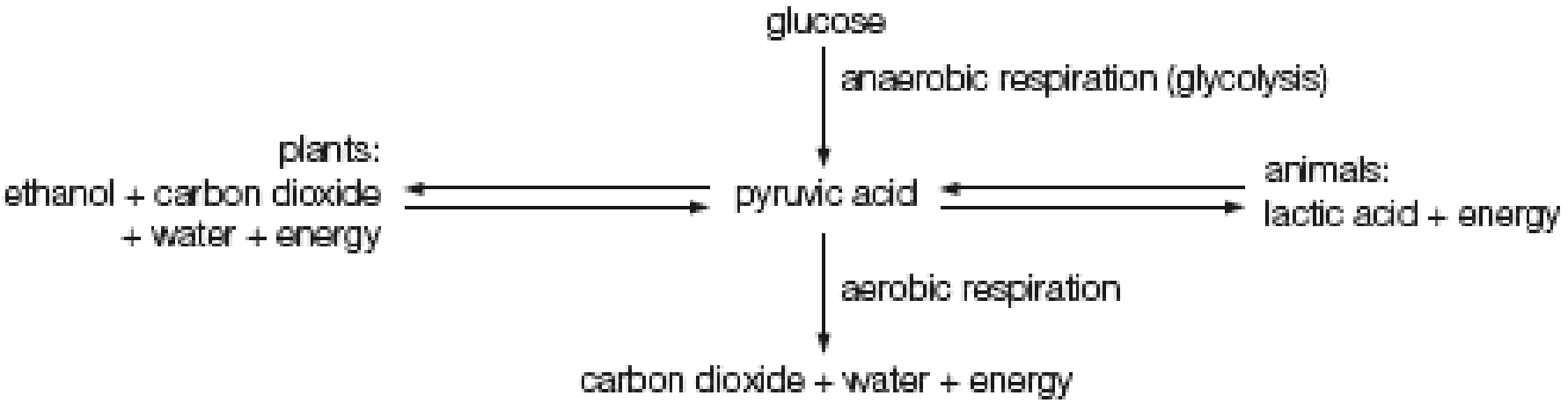
- Aerobic and Anaerobic respiration are not alternative metabolic pathways
- Anaerobic respiration comprises the first steps in a much longer series of reactions which only occur under aerobic conditions. (stops bc no oxygen)
- Pyruvic acid, $C_3H_4O_2$, is common to all three pathways.

	Anaerobic	**Aerobic**
Molecular oxygen requirement	Nil	Essential
Useful energy from each glucose molecule	Small (2 ATP molecules)	Very large (38 ATP molecules)
Chemical products	Organic	Inorganic
Site of reaction	Cytoplasm	Mitochondria

Table 22.11 Comparison of the two stages of cellular respiration

B9.1 – Respiration Pathways

- Various steps of respiration based on available oxygen and the host of reaction



B9.2 – Copper Ion Role

- B.9.2 Outline the role of copper ions in electron transport and iron ions in oxygen transport

B9.2 - Cytochromes

- **Cytochromes** are a group of proteins involved in respiration.
  - They contain a **heme** group with a datively bonded iron ion which is able to reversibly interconvert between iron (II) and iron (III)
  - $Fe^{2+} \rightleftharpoons Fe^{3+} + e^-$
  - Also found in chlorophyll
  - **Electron transport**
  - In both animal and plant cells
  - Reduction of O_2 to water
    - $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$

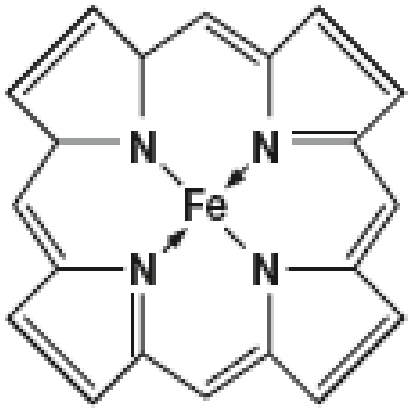


Figure 22.115 Structure of the heme group

B9.2 – Cu containing cytochrome

- The terminal electron carrier, **cytochrome oxidase**, contains Cu as well as Fe.
- Copper changes between +1 and +2 as electrons flow through.
- This is the site where cyanide acts
  - Inhibits the enzyme and so blocks the electron transport chain thus preventing aerobic respiration from occurring.

B9.2 - Hemoglobin

- A large globular protein present in red blood cells that transports oxygen from the lung to the body cells.
  - Each hemoglobin contains 4 polypeptide chains and 4 heme groups (each with a iron (II) ion).
  - The reaction between hemoglobin (Hb) and oxygen can be represented as:
    - $Hb + 4O_2 \rightleftharpoons HbO_8$
    - Forward rxn: favored in capillaries surrounding lungs due to high concentration of oxygen
    - Revers rxn: favored in capillaries near body cells where oxygen concentrations are relatively low.

B9.2 – Oxy-hemoglobin

- In **oxy-hemoglobin** the iron (II) ion is hexa-coordinated
  - 5 of the sites are occupied by nitrogen
    - 4 from heme ring system
    - 1 from histidine residue from polypeptide (globin)
  - 1 coordination is occupied by oxygen which is reversibly bonded.
  - Other ligands such as cyanide, nitrogen monoxide and carbon monoxide, are irreversibly bonded at the same site (due to similar size).
  - The presence of these makes is impossible fore hemoglobin to transport oxygen, making them toxic